LCA: Defining the Undefinable, Quantifying the Unquantifiable

Abstract

"Life Cycle Assessment: Defining the Undefinable, Quantifying the Unquantifiable"

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The US Environmental Protection Agency (EPA) defines Life Cycle Assessment (LCA) as the evaluation of products, processes and activities using a multi-media, "cradle to grave" approach. An LCA framework can be used to gather information to make comparisons between competing products performing the same function, or in evaluating a modification to a system to make it more "environmentally friendly." LCA is an important process to identify when a change has the desired end result of decreasing overall environmental impacts, from all life cycle stages and across all media (air, water, and solid waste). Identifying unanticipated shifts of environmental impacts across the life cycle is the key concept behind LCA.

Both industry and government are beginning to evaluate decision options using a life cycle framework. Many key industries, such as automotive, building, electronics, and chemical production, are regularly using life cycle thinking in product development and design. In the federal government, the 1998 Executive Order 13101 on "Greening Government" has been a major force in bringing LCA to the attention of policy makers and procurement officials. EPA's Office of Research and Development has an active program in LCA including several on-going projects involved in life cycle assessment methodology development and application. (See http://www.epa.gov/ORD/NRMRL/std/sysanal.html for project descriptions)

This presentation describes the basic principle behind LCA and explores the need to use life cycle thinking in environmental decision-making. Examples of life cycle assessments of solvent substitution, paper recycling and chemical production from bio-based feedstocks are presented.

Slide Presentation

"Life Cycle Assessment: Defining the Undefinable, Quantifying the Unquantifiable"

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End users are evaluating their business with LC thinking

- Automotive
- Building Industry (e.g., ASTM Green Building Standards)
- Electronics
- Chemical (e.g., Product Stewardship Management Code)
- DOD (e.g., Weapons Systems Acquisition)
- Government Purchasing (e.g., EPP)

ISO is developing LCA series of standards

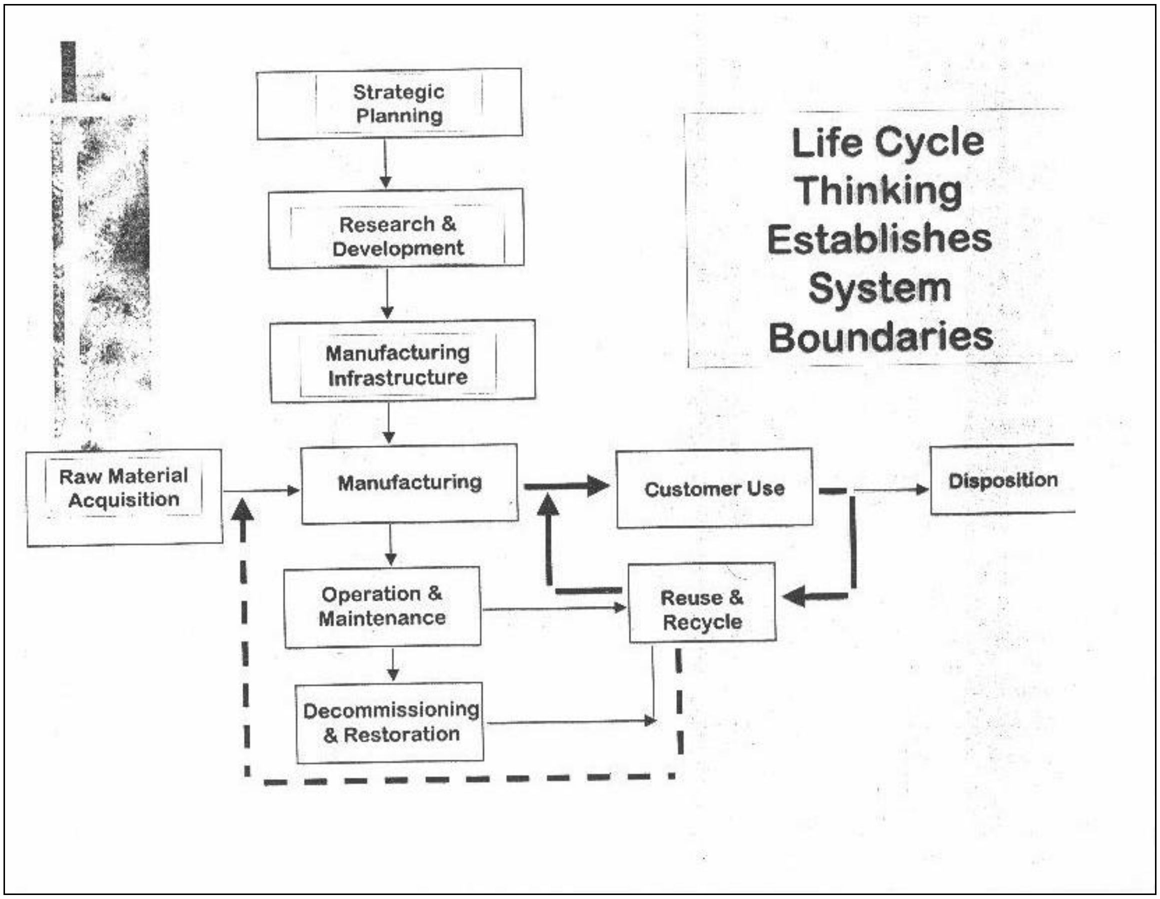
LCA can be used to assist in:

- Pollution prevention initiatives
- Resource conservation efforts
- Internal benckmarking and improvement efforts
- Understanding global impact concerns
- Triggering additional environmental assessments on local or regional levels

Life Cycle Thinking

Life Cycle Thinking **is a powerful systems approach for considering technology from a cradle-to-grave perspective**

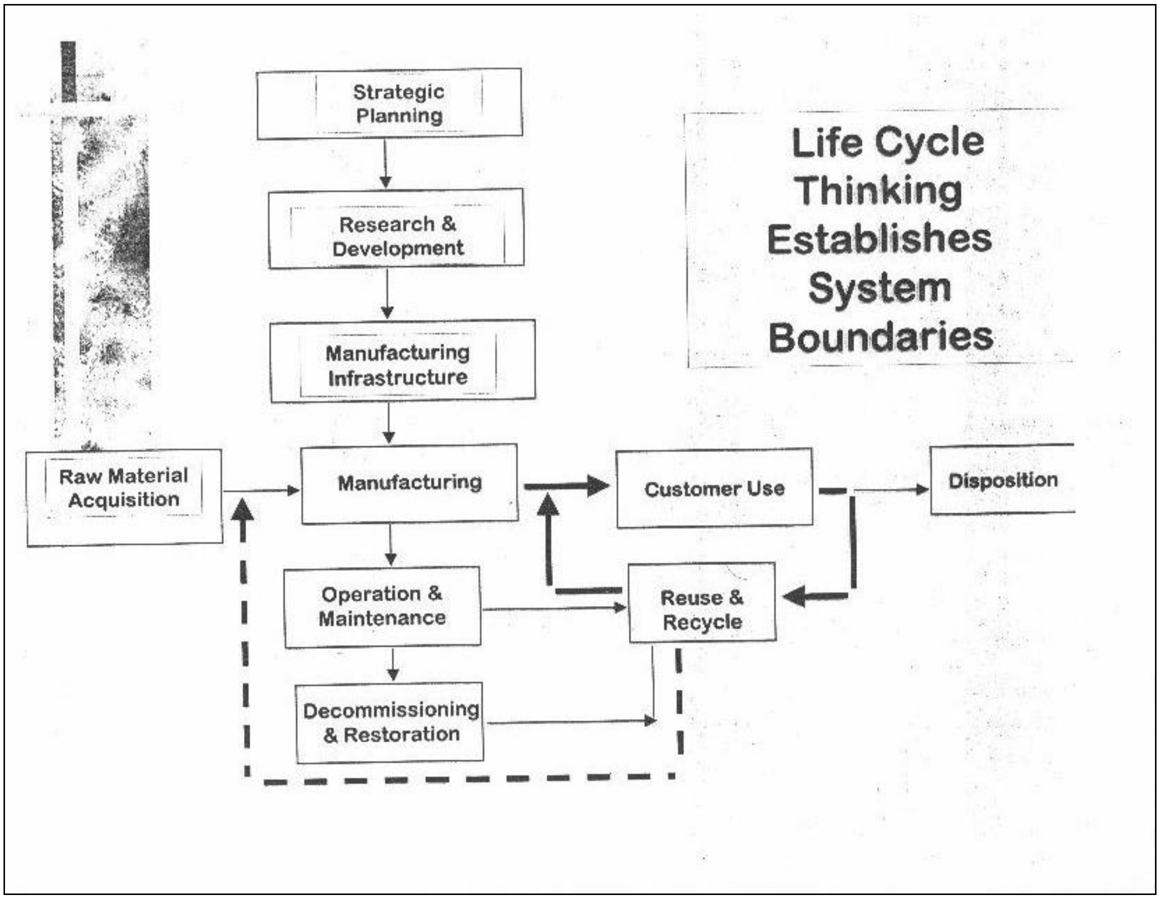
Life Cycle Assessment (LCA) **is an analytical tool for implementing life-cycle thinking**


Life Cycle Thinking Establishes System Boundaries
Strategic Planning
Research & Development
Manufacturing Infrastructure
Raw Material Acquisition
Manufacturing
Customer Use
Disposition
Operation & Maintenance
Reuse & Recycle
Decommissioning & Restoration

Life-Cycle Thinking Establishes System Boundaries

and considers:

- the environmental impacts along a product or process life cycle (ie from cradle to grave)
- for all media (ie air, water, & solid waste)
- to identify potential impacts (chemical and non-chemical stressors)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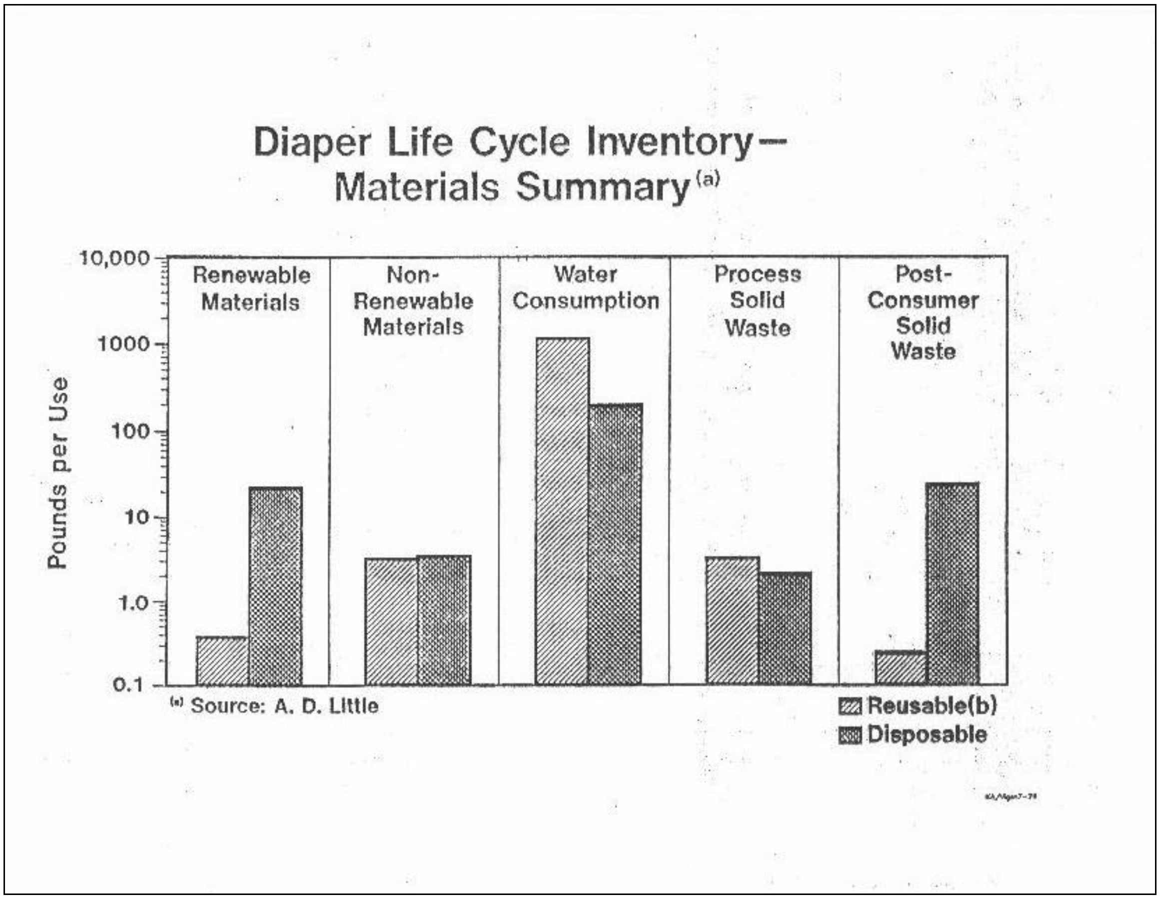
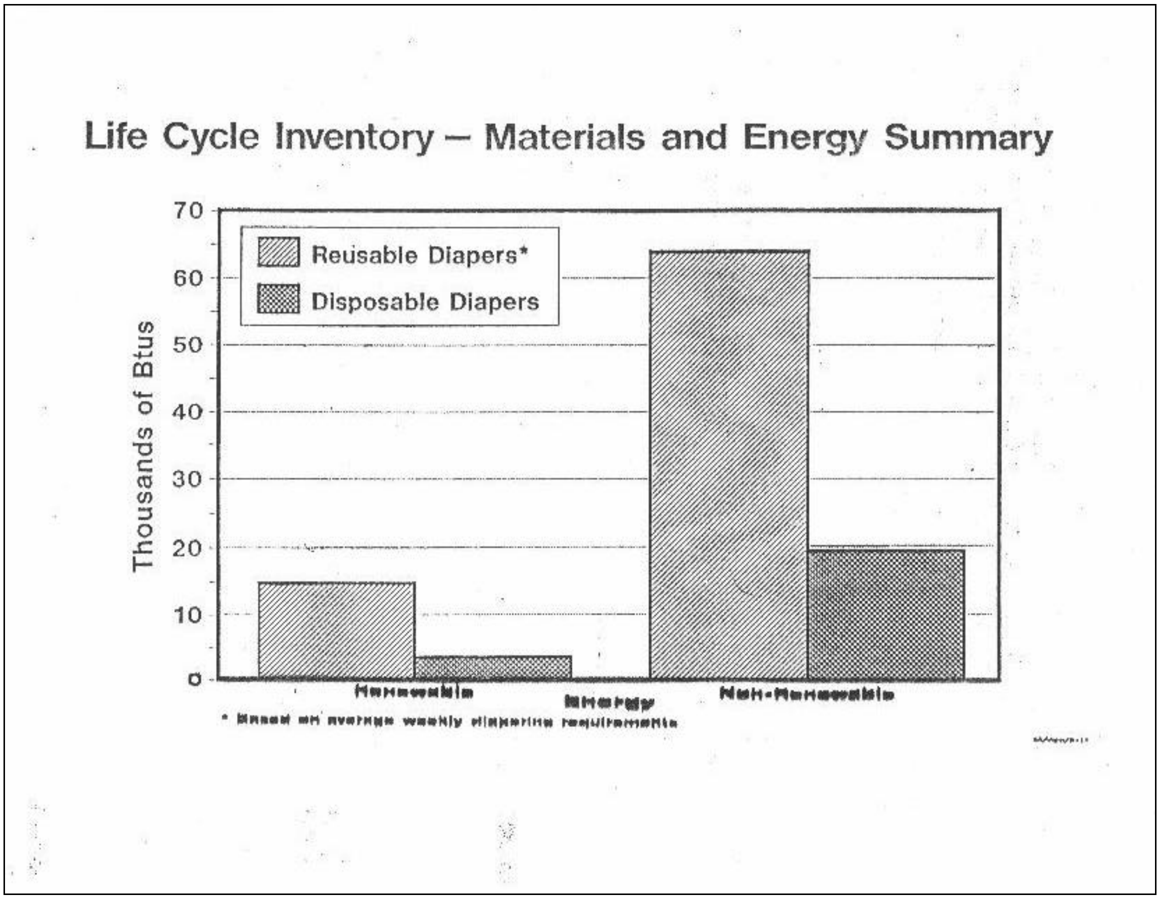
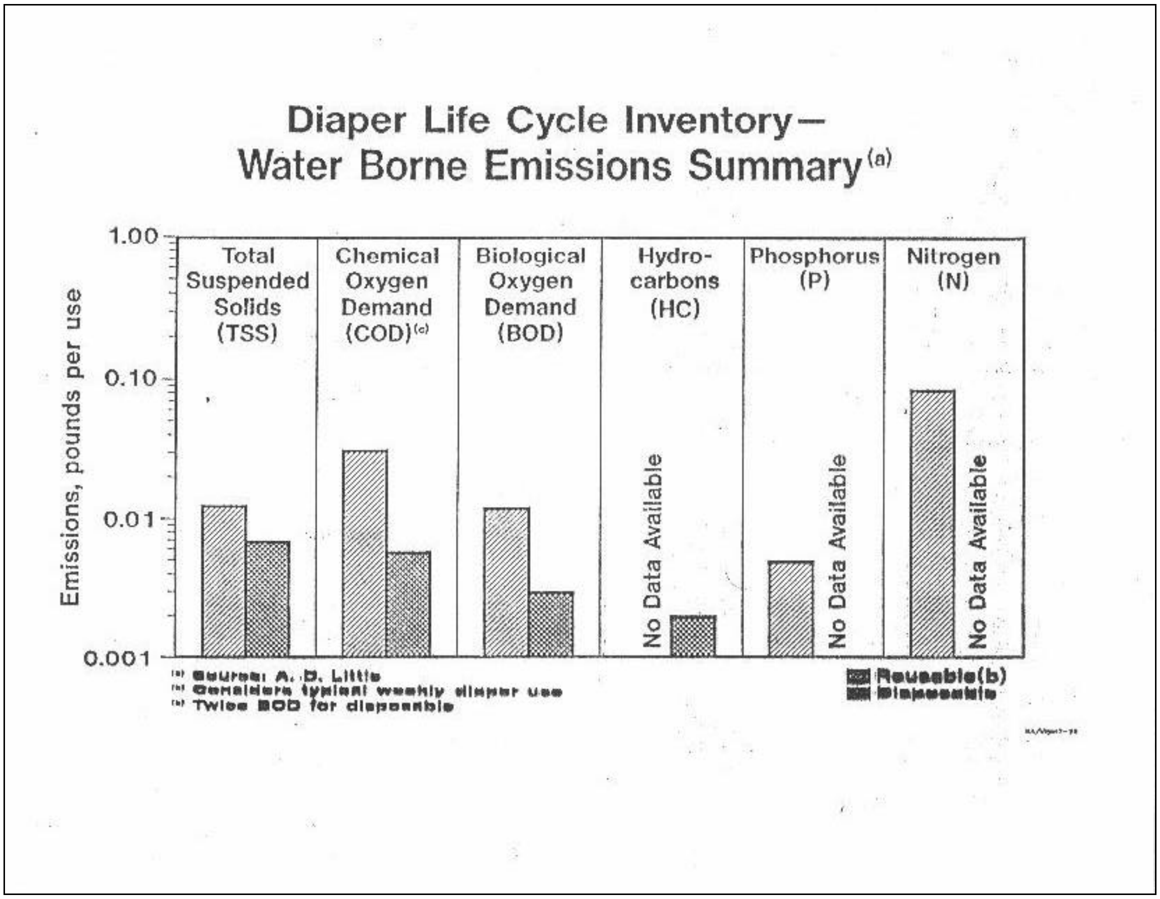
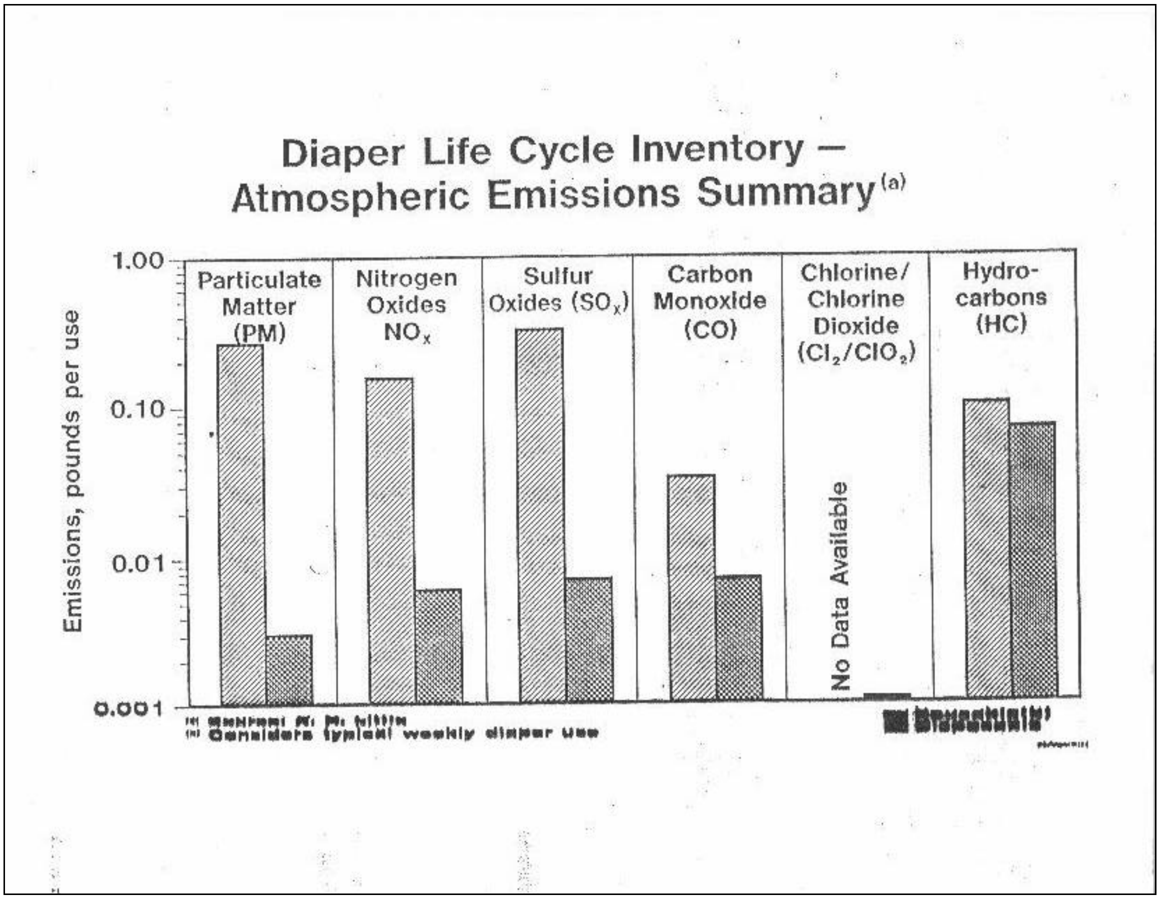


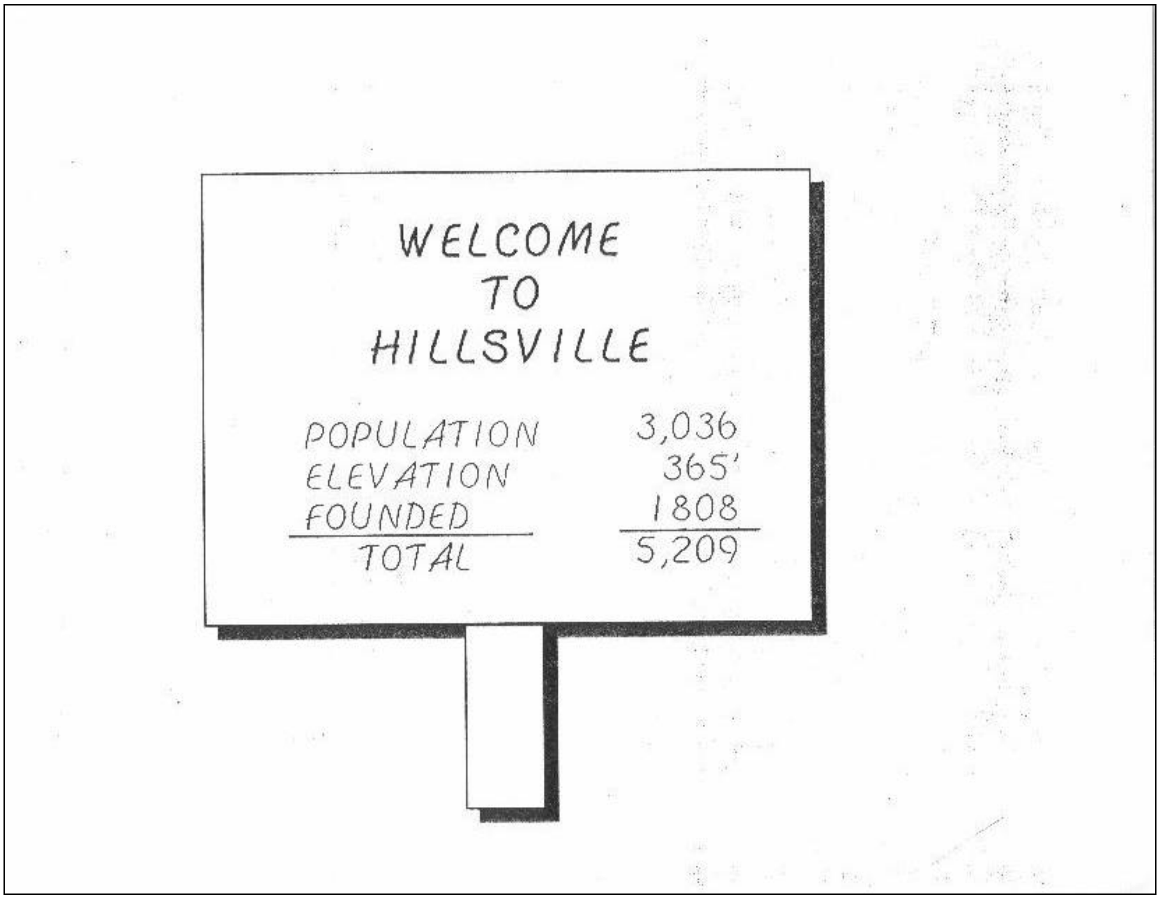
Diaper Life Cycle Inventory—
Materials Summary(a)
Renewable Materials
Non-Renewable Materials
Water Consumption
Process Solid Waste
Post-Consumer Solid Waste
Pounds per Use
10,000
1000
100
10
1.0
0.1
(a) Source: A. D. Little
Reusable(b)
Disposable

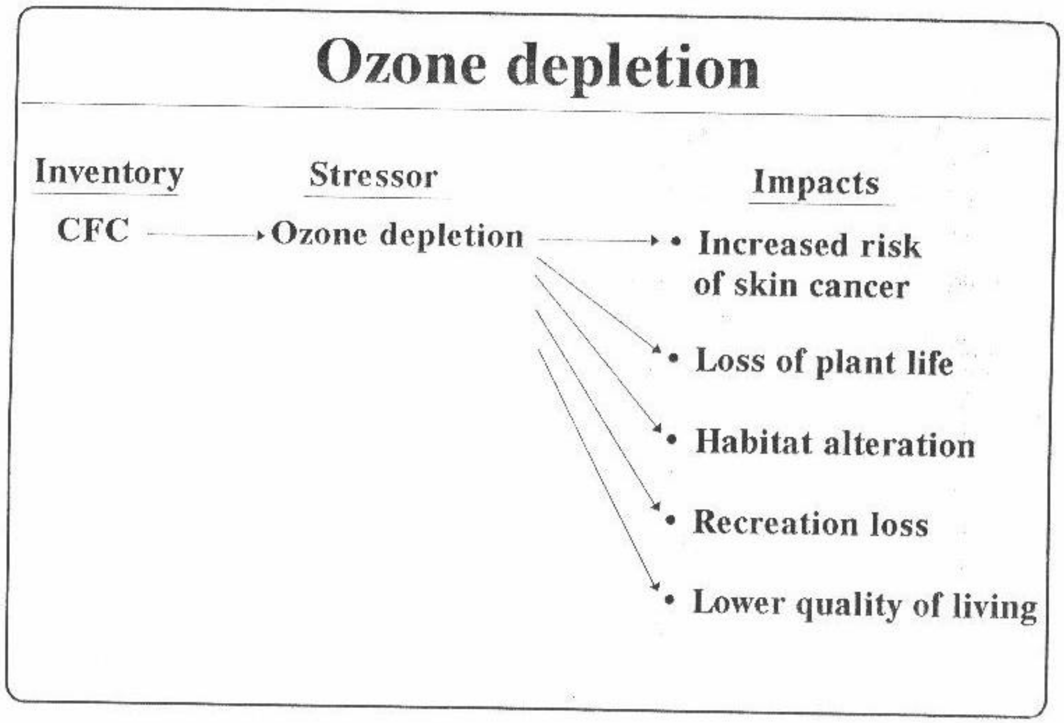


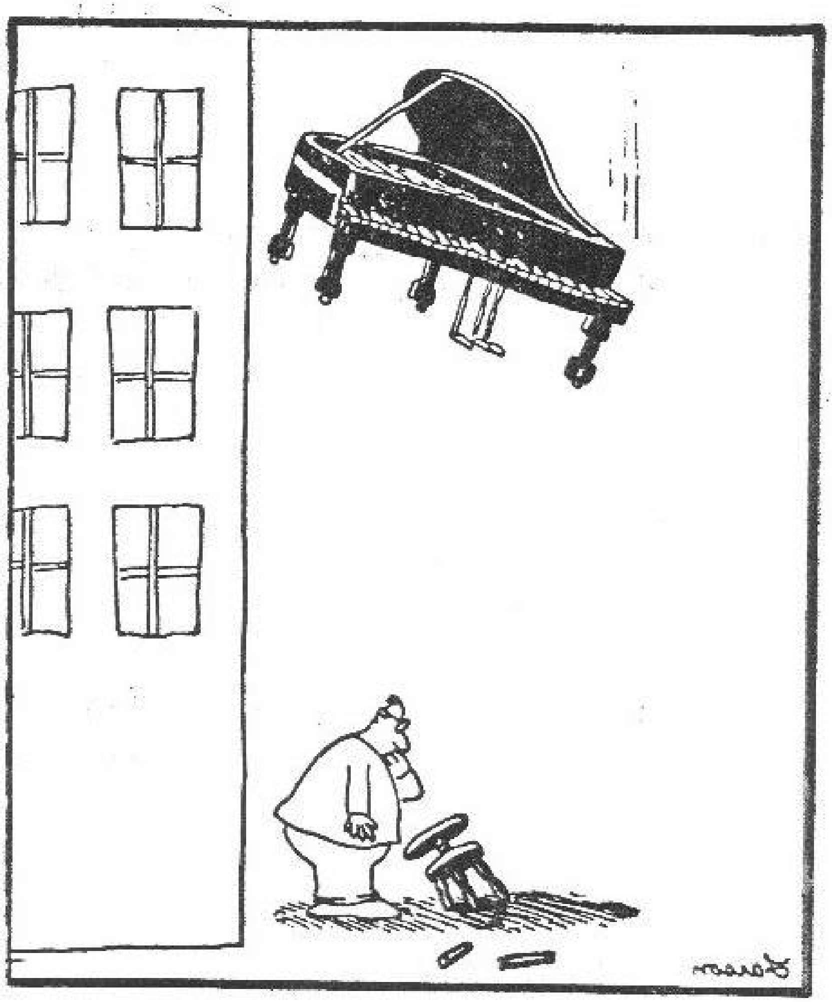
Life Cycle Inventory – Materials and Energy Summary
Reusable Diapers*
Disposable Diapers
Thousands of Btus
70
60
50
40
30
20
10
0


Diaper Life Cycle Inventory—
Water Borne Emissions Summary(a)
Emissions, pounds per use
1.00
0.10
0.01
0.001
Total Suspended Solids (TSS)
Chemical Oxygen Demand (COD)(c)
Biological Oxygen Demand (BOD)
Hydro-carbons (HC)
Phosphorus (P)
Nitrogen (N)
No Data Available
No Data Available
No Data Available
(a) Source: A. D. Little
(b) Considers typical weekly diaper use
(c) Twice BOD for disposable
Reusable(b)


Diaper Life Cycle Inventory —
Atmospheric Emissions Summary (a)
Emissions, pounds per use
1.00
0.10
0.01
0.001
Particulate Matter (PM)
Nitrogen Oxides NOx
Sulfur Oxides (SOx)
Carbon Monoxide (CO)
Chlorine/ Chlorine Dioxide (Cl2/ClO2)
Hydro-carbons (HC)
No Data Available


WELCOME
TO
HILLSVILLE
POPULATION 3,036
ELEVATION 365'
FOUNDED 1808
TOTAL 5,209


Ozone depletion
Inventory
Stressor
Impacts
CFC
Ozone depletion
• Increased risk of skin cancer
• Loss of plant life
• Habitat alteration
• Recreation loss
• Lower quality of living



United States
Environmental Protection
Agency

Office of Research and
Development
Washington DC 20460

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EPA

Development of a Pollution Prevention Factors Methodology Based on Life-Cycle Assessment

Lithographic Printing Case Study

P2 FACTORS FOR LITHOGRAPHIC PRINTING

- SOLVENT SUBSTITUTION FOR BLANKET OR PRESS WASH
- USE OF WATERLESS VERSUS CONVENTIONAL PRINTING

LCA IN PROCESS IMPROVEMENT

Example: Paper recycling

Reduces amount going to the landfill and requires less total energy

But

Recycling may generate more emissions by burning fossil fuels for energy (instead of burning byproducts as in virgin fiber production)

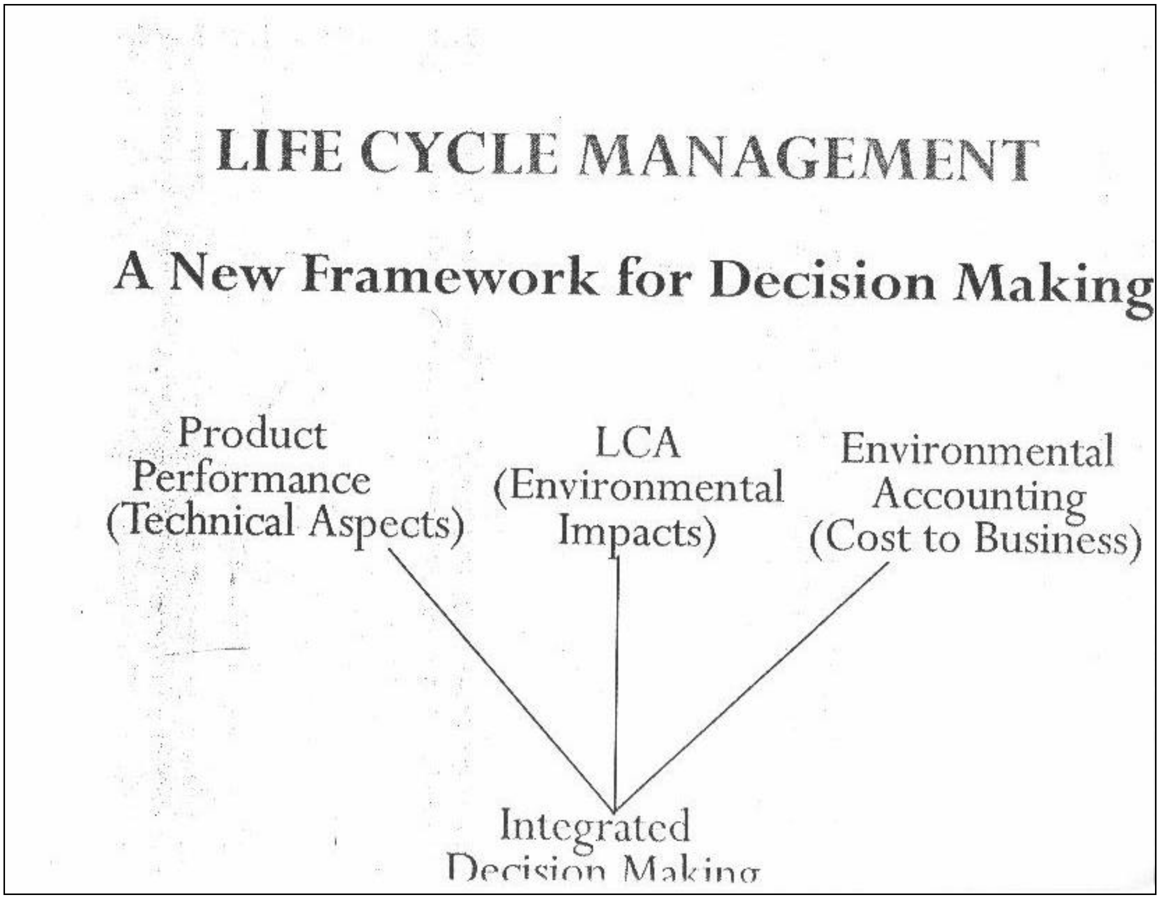
Opportunity to improve the recycling system by altering energy source/demand.

Source: Journal of Industrial Ecology (2.2)

Water Emissions	Conventional Process	Alternative Process	Minimum Process
BOD_5	3.88E-08	1.67E-03	C
COD	1.74E-07	1.59E-06	C
TSS	8.43E-08	2.29E-03	C
Nutrients	0	2.07E-03	C
Soluble Salt - Cation	1.27E-03	1.15E-02	C
Soluble Salt - Anion	1.00E-03	1.98E-02	C
Acids	2.50E-04	2.30E-03	C
TDS	4.12E-05	3.77E-04	C
Hydrocarbons	4.95E-05	2.37E-07	A
Oxyhydrocarbons	40.8E-05	1.19E-07	A
Iron	7.84E-04	7.19E-03	C
Heavy Metals	2.14E-06	0	A
Chlorine	0.00	5.04E-08	C
Sulfide	1.29E-08	1.19E-07	C
Pesticides	0.00	6.71E-06	C
Solid Wastes	**Conventional Process**	**Alternative Process**	**Minimum Process**
Energy Generation	5.03E-02	4.62E-01	C
Hazardous Process	1.54E-02	5.59E-07	A
Solid Wastes	0	2.76E-01	C
Energy Use (Btu/lb)	**4.34E+04**	**3.66E+04**	**A**

C = conventional process
A = alternative process

From "Streamlined Life-Cycle Assessment of 1,4-Butanediol Produced from Petroleum Feedstocks Versus Bio-Derived Feedstocks," (Draft EPA report, September 1997)


LIFE CYCLE MANAGEMENT
A New Framework for Decision Making
Product Performance (Technical Aspects)
LCA (Environmental Impacts)
Environmental Accounting (Cost to Business)
Integrated Decision Making

Life Cycle Advancement Research Projects

Life Cycle Assessment

- Cleaner Products Through Life Cycle Design
- Enhanced Methods for Life Cycle and Total Cost Assessments
- Improved Chemical Agent Resistant Coating (CARC) LCA
- Life Cycle Engineering and Design (LCED) Program
- MEK Substitute in Aircraft Radome Depainting
- Localizing Life Cycle Assessment
- Streamlined LCA Model Development and Demonstration
- Streamlined LCA Practices
- LCA for Environmentally Preferable Products
- Cleaner Products Design Project

Impact Assessment and Measurement

- Development and Demonstration of LCA Methodology for an Environmental Bioprocess
- TRACI: Tool for Reduction and Assessment of Chem. Impacts

Engineering Trade-Off's

- Engineering Trade-Off Assessment Case Studies
- ETO Benefit/Cost Assessment Guide and Case Studies
- Physical Vapor Deposition (PVD) of Tantalum

Conclusion

- Life cycle thinking is surfacing more and more in government and other initiatives
- Life cycle thinking is involved with environmental aspects and impacts, eco-labeling, and environmental performance evaluation within ISO
- LCA is only one possible tool to assess aspects and potential impacts of product systems

Interest in LC is increasing - not decreasing

Speaker Biography: Mary Ann Curran

Present: Life Cycle Assessment Expert, Office of Research and Development; International Standards Organization (ISO); LCA subcommittee; Canadian Standards Association (CSA); ASTM LCA

Previous: Society of Environmental Toxicology and Chemistry (SETAC); Board Member International Journal of Life Cycle Assessment

Education

Masters degree in Environmental Management and Policy from Lund University, Lund, Sweden (1996).
B.S in Chemical Engineering from the University of Cincinnati, Cincinnati, OH (1980)

Mary Ann provides technical review and assistance both internally and to outside groups on clean product design and development. She has participated in the technical peer review of industry-sponsored life=cycle studies, including diapers, cleaners, plastics, coal ash and steel, and represents the Agency in two international activities for establishing LCA-based guidance: The International Standards Organization (ISO) LCA subcommittee and the Canadian Standards Association (CSA) life-cycle design committee. She is also EPA's representative to the ASTM CA committee.

She has authored and co-authored numerous papers which address LCA concepts and applications, including editing a book entitled "Environmental Life Cycle Assessment" which was published by McGraw-Hill in July 1996, and has presented EPA's activities in LCA-related research at technical meetings across the U.S. and in Europe